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ABSTRACT

Technological literacy has become an indispensable part of general culture. Vocational education must simultaneously provide students with the special and general qualifications required to achieve increased productivity and flexibility. The concept of technological capabilities is based on the pillars of general technology, technical systems, and innovation and design. The development of technology education lends itself to a modular approach. As technology education continues to develop, it can be systematized to include the laws and principles of technology, the structure of technological processes, the design of technical products, and the process and principles of innovative thinking. A model can be developed whereby education about technology and education through technology can be provided. Education can function to identify situations that help people develop the abilities to overcome barriers. The following are among the terms in which technology education must teach students to think: stages of development, variables and decisions, technological assessments, hierarchical and time-oriented systems, analogies, and contradictions and compromises. A series of 27 principles of technology should be taught in learning modules based on a cognitive development model that proceeds from preoperations to concrete operations to abstract operations. (Contains 25 figures, 17 references.) (MN)

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ED 360 517

The Elements of Technology for Education

INTREEREDE

Prof.dr.ing. D. Blandow

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Eindhoven.

Prof.dr.ing. D. Blandow

Technology is the knowhow and creative process for using tools, resources, environmental conditions and personal capabilities in order to realize objectives and change conditions as well as help individuals to overcome contradictions in typical situations.

Mijnheer de Rector Magnificus,
Dames en Heren,

Forty years ago, I started my vocational carreer as a motor mechanic apprentice. I don't think it will cause infringements if I say that - it was a small Opel contracted workshop in Cottbus, near the border with Poland. With only one foreman we had to do everything: in the morning repairing engines, in the afternoon, electrical engineering in the evening, as a part of overtime to earn extra money we worked with sheet metal and paint. It was long ago, but with reference to today's subject, I must say it was an integrated and interdisciplinary learning experience.

Only some weeks ago, General Motors started a new factory, in Thueringen, one of the new areas of Germany, in Eisenach where 180 thousand cars per year, will be produced, but with only 2.800 employees, which is half the normal for similar companies in Europe. The key is again an integrated and interdisciplinary concept. This means all activities from fiber-optics to hydraulics, from steering gear to electronic ignition in the final cars, as well as, the automatic tools have to be adapted to suit the workforce.

In addition, now, production will involve a groups, working in parallel. The complexity of technological processes, and interrelationships requires an interpersonal group concept with a high level of flexibility, responsibility and communication.

What I would like to explain with the following examples is that the accepted situation between humans and their technological environment is one of development relationships. We see this not only in the field of production, but also in our leisuretime, in our safety aspects, in the areas of sports, of communications and hospitality. But the relationships between humans and their environment are irreversible. You can't omit some stages, nor can you ignore the existing levels. Yet the main point is that advanced technology itself is the result of human activities with their social, natural and physical interfaces. At the same time, that the man-used and man-made world is a result of both theoretical and practical efforts, and it is reflected in all aspects of our lives, see Figure 1.

Fig. 1. Technology and Human Resource Development.

On the other hand, the relationships between humans and technology relations are already curious. More and more ideas are put into practice and each generation finds it increasingly more difficult to work with accumulated experiences increasing exponentially in number and complexity. The consequences of this, the well-known knowledge-time-problem, are accepted; however, the later consequences, the knowledge of technology, from which other things came, meals, safety, traffic, communications, medical health, our future ecological environment, is not yet accepted as a part of general education everywhere.

And hereby we include not only the young, but the older people, the unemployed as well as the daily workers should be kept in mind. In reality, most scientific results in the field of high technology never reach the people in practice. This raises questions about the different views of society and the purpose of manufacture. And it involves the ethics of technology and the social responsibility of companies. During the UNESCO Bangkok Conference on Technology Education in 1989 this phenomena was explained with the opposite term to technological literacy, namely technological illiteracy.

When we are looking for a starting point in order to explain the pedagogical dimension of the human technological interface and to understand the changes, risks, laws and principles of technology, we need to consult Figure 2.

One outcome of this chart is the need to know what general culture is and which role technology plays in life. In my opinion, general culture (which is the basis of professional culture and economical success too) must be a

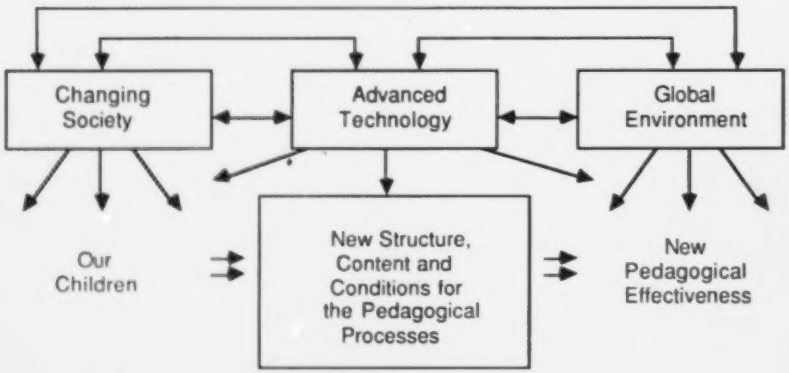
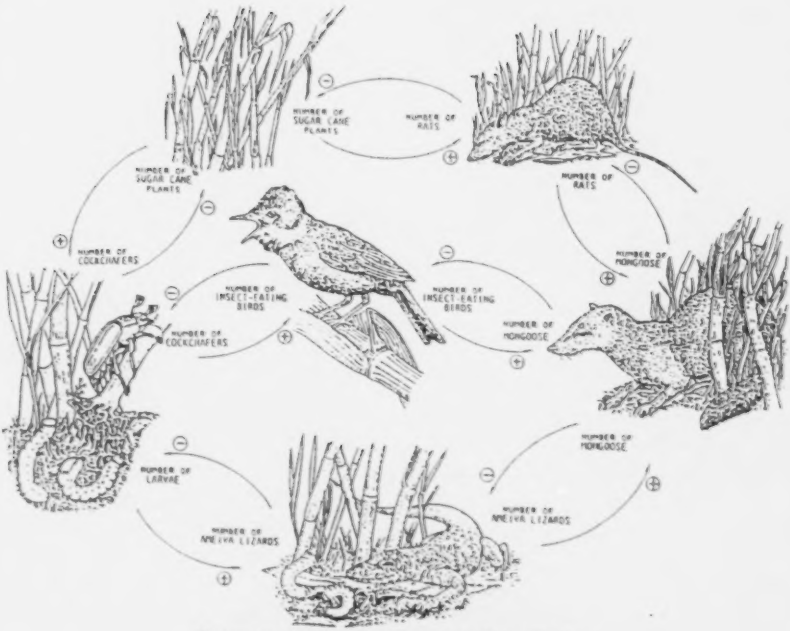


Fig. 2. Finding the Starting Point.



Sugar Cane ← Razed by Rats

⇓

Mongoose imported by man

⇓

Rats eaten by mongoose

⇓

Rats exterminated

⇓

Mongoose switch to eating birds

⇓

Excessive population of insects

⇓

Disruption of ecosystem

⇓

Sugar Cane ← Razed by Insects

Fig. 3. Consequences of short-sighted thinking.

symbiotic complex of related knowledge and purposeful behavior that enables people:

- to orient themselves to their environment (in space and time);
- to adapt themselves actively to that environment;
- to protect her or his environment and, finally;
- to develop themselves.

Nowadays, technological education (which is synonymous with Technological Capabilities and Technological Literacy) is part of the general culture without which it would not exist. This is not a technocratic view. On the contrary, it reflects the fact, that illiterate people can destroy our natural environment and society too. Therefore the conditions of human life and humanity itself would be destroyed. Technological literacy and the success of society as a whole are irreversibly connected. Let me explain this with a simple example. One part of technological literacy concerns thinking in a hierarchical and time-oriented manner. Shortsighted thinking has consequences which become apparebt later, sometimes years later, as shown in Figure 3.

Before I explain the ideas behind the concept of technological education as a part of general education, let me highlight the paradigm changes in vocational training and engineering subjects. It is sometimes easier to solve your own problems if you know something about your colleagues.

In vocational eduction, companies are using the so-called Synergetic Competence Model as a starting point, refers Figure 4.

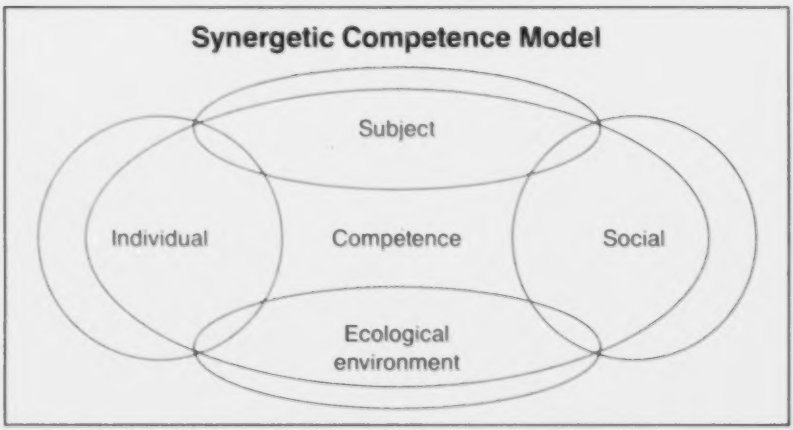


Fig. 4. Synergetic Competence Model.

From this model, the demands on vocational training have been listed in Figure 5.

Thinking of the technological knowledge-time-problem in engineering terms leads us directly to the structure of key-qualification. The example from BMW for instance compares not only the differences between the nominal profile of BMW and its trainees, but also between it and the graduates from colleges and universities too.

Now, I must come back to technological literacy as a part of general education. I think that the general standard of technological education in our culture will be a precondition for success in the future and it will influence investors. This is especially important for Eastern Europe and developing-countries. In addition to natural resources and the social structure of a region the educational standard, the suitability of technical skills will influence the desisions of investors. Especially when we look at Eisenach, the new General Motors enterprise, or Jeneoptic (the former Carl Zeiss Jena) or Chemnitz, Dresden and other places in Eastern Europe, the educational standard was and will still be an important desision criteria. Thinking in terms of systems, hierarchies and analogies, thinking in terms of variables, contradictions and compromises and being able to formulate technological problems are common denominators for a development-oriented educational system. Let me explain in more detail what are the starting points for the conception of technological education in the field.

DEMANDS ON VOCATIONAL TRAINING		
	TRAINING FOR	
	PRODUCTIVITY:	FLEXIBILITY:
special qualifications	requires abilities that fullfill the demands of the working place (highly qualified and specialized)	requires basic training for different work places (wide and applicable)
general qualifications	need to be ready for action, efficiency, high-quality work, resistant to stress and tireless	need to be adaptable, able to learn on the job, creative, ready to work elsewhere, ready to work in a team, analytic, capable of independent planning, descerning, communicative and ready to make a decision
PRODUCTIVE (PROFESSIONAL QUALIFICATION) +	FLEXIBLE (VARIETY OF DEPLOYMENT) =	SKILLED WORKER'S

Fig. 5. Demands to the Vocational Education.

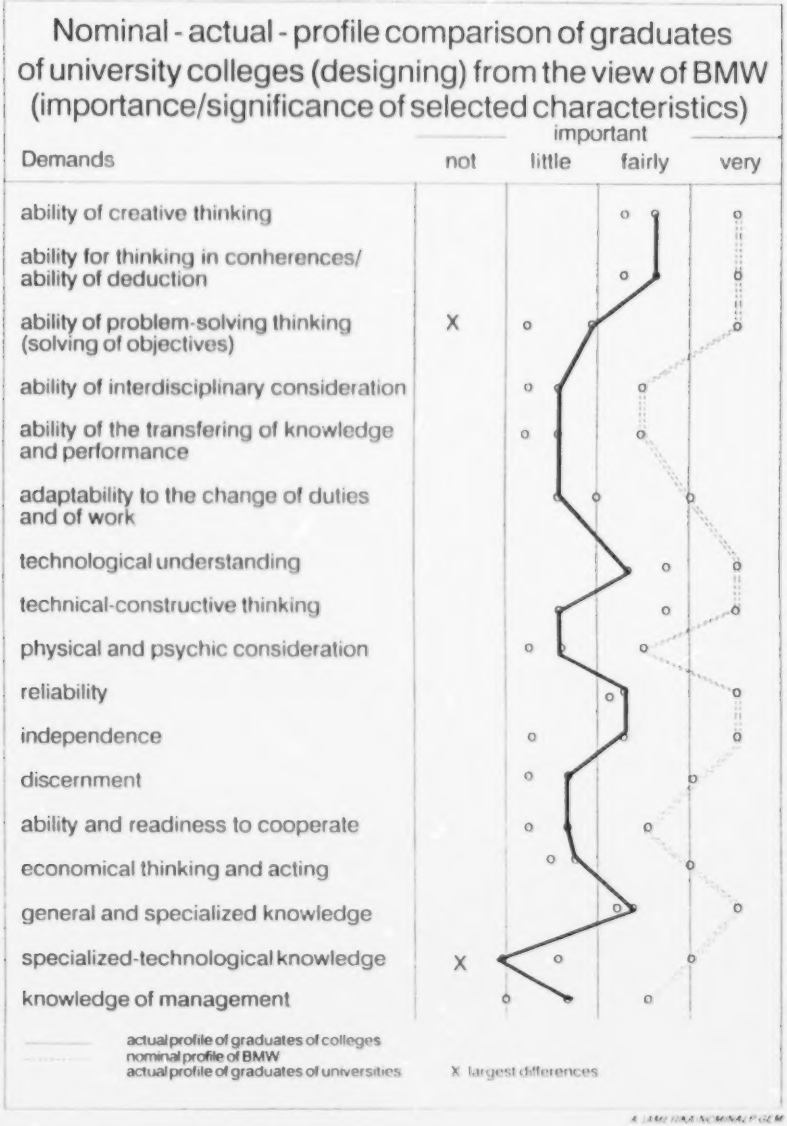


Fig. 6. Nominal-actual-profile comparison.

Framework model

The concept of technological capabilities is based on the pillars of general technology, technical systems (the theory of artifacts) and innovation and designing. This means that we have to accept a complex and interdisciplinary situation in association with a Metatheory, its language and struc-

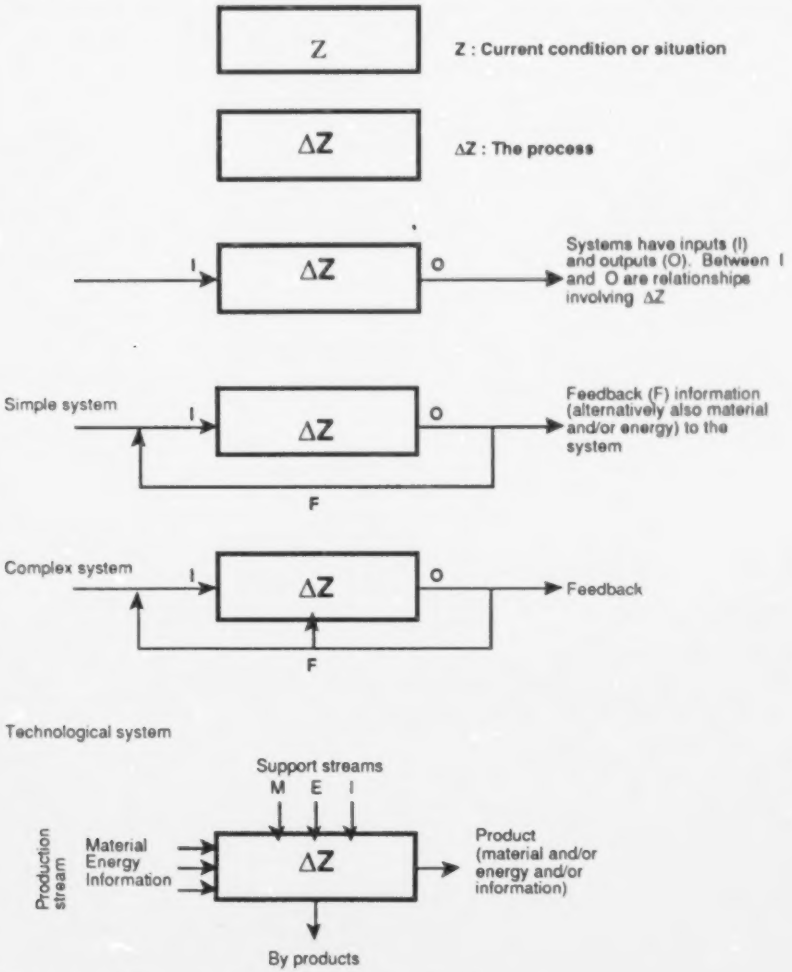


Fig. 7. Key elements of technological processes.

ture. Therefore, we must be clear about two things:

1. There are natural overlaps between disciplines
2. The development of a framework depends on interrelationships between disciplines and differences between their perspectives and approaches.

Metalanguage includes:

Function: The ability of technical skills and technological conditions to design processes.

System : A complex set of connected components within a hierarchy.

Systemborder, systemheart, systemenvironment, structure and functional principles, technological principles, are terms that indicate the kind of thinking needed. The key to developing the ability to arrive at the correct answer is to find the right starting points; especially, for technological subjects, the key to all technological solutions are known from the terms Z and Δ Z (see Figure 7).

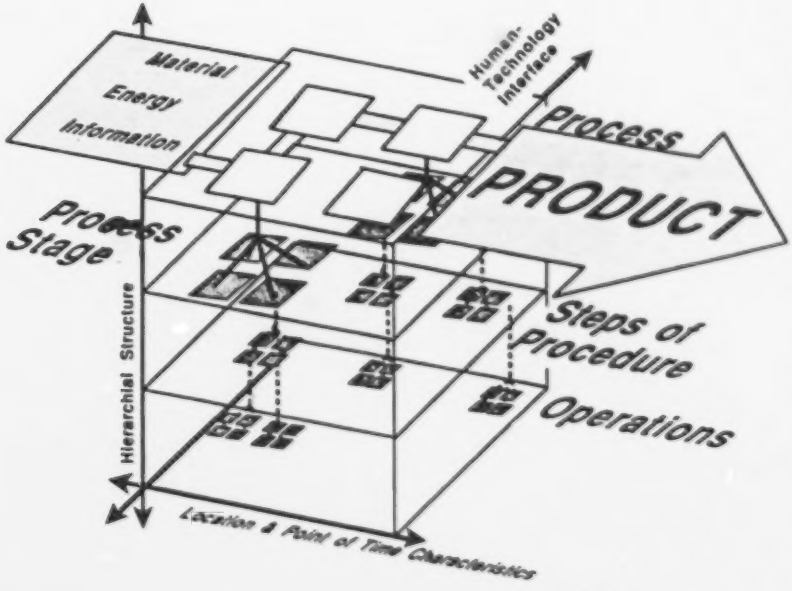
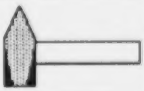
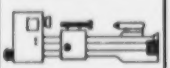
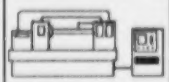
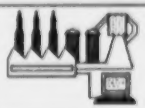


Fig. 8. Hierarchical structure of production process.

Keypoints for understanding technical products and processes are the condition or situation, the changing of conditions or situations, the relations between input, output and feedback. The pertinent question here is in fact the key question. It is not so important to know what is being produced. Instead, the salient issue is what changes and processes are being used, this means on which level we are processing. In other words, the profiles and interaction between the levels should be part of the technological education. In reality, those keys interact on various planes and levels (see Figure 8).

FUNCTIONAL SYSTEM	W.O.	S.O.	T.O.	D.O.	G.O.	P.O.	C.O.	O.O.	EXAMPLE
TOOLS	+	+							
DEVICES	+	+	+						
SIMPLE MACHINES	+	+	+		+	+			
TRADITIONAL MACHINES	+	+	+	+	+	+			
NC - MACHINES	+	+	+	+	+	+	+		
INTEGRATED MACHINES	+	+	+	+	+	+	+	+	

W.O. WORKING ORGAN
S.O. SUPPORTING ORGAN
T.O. TRANSMITTING ORGAN
G.O. GUIDANCE ORGAN
D.O. DRIVING ORGAN
P.O. POSITION ORGAN
C.O. CONTROL ORGAN
O.O. OPTIMIZING ORGAN

Fig. 9. Hierarchy of technical systems.

The structure shown in Figure 8 may be used to describe, explain or analyze production in any of the areas typically used by the learners. The model is equally applicable to traditional paper, metal, wood or plastics-industries, as well as, to food processing including cheese, sugar, meat and milk, or process industries such as petrochemicals, derated water or biotechnology. Furthermore, although less obvious the model clearly also fits agriculture. The same situation is shown in the hierarchy of technical systems, shown in Figure 9.

Other models of connecting are available for the different levels and stages in a so-called Life Cycle of Technical Systems.

As a result of this attempt to make sense of technology, it will be useful to make a model to represent the range of production, in the form of a matrix with three pillars (materials, energy, information) against the nature of change (shape, structure, location, time). It is shown in Figure 10.

If the principles of technological organization are included together with the proceeding matrix, one arrives at the principles of development for production. This combination is depicted in Figure 11 and it will become a most useful tool to help us understand the strategies needed for solving specific technology/innovation problems.

First Consequences

The preceding analyses of technological systems and technical products led me to consider a modular concept for Technology Education. Figure 13 presents an overview of such a concept, it shows the constants of the problem-solving process at the Human-Technology-Interface along the X axis; the key objective of technology along the Y axis; and the key technological processes along the Z axis.

Object of work	Nature of Change			
	Form/Shape	Structure	Location	Time
Material	Material shaping	Reconstituting	Materials handling	Aging, Wine, Patina
Energy	Energy processing	Energy conversion	Energy transfer	Half-life
Information	Information handling	Information processing	Communication	Obsolescence

Blandow/Dyrenfurth, 1991

Fig. 10. Matrix of objects of work against nature of change.

Sample goals of process operation	Implications of the Goals on:			
	Changing conditions or situations, Z1, Z2, Zn	**The process, ΔZ**	**Location and point of time characteristics**	**The technical artifacts/ means**
Minimization of resources	Capitalization on material characteristics [Material structure]	Process integration WRT time [Work hardening]	Production timing (continuous/ intermittent) [continuous casting, Just-in-time organizing]	Energy supply at point of use [Solar telephone, Integral wheel-motors]
Increase of variability	Substitution, Alternative sequences [Recycled material aggregate]	Adaptation [Photochromatic glass]	Flexible reactions [Combine threshing drum pressure]	Standardized components [Microchip logic elements]
Increase of stability	Feedback systems [Sensor technology, Dash warning indicators]	Networking, optimization [Feedback driven control systems, assembly line buffers]	Quality assurance [Zero defect programs]	Parallel/ redundant structure [Pilot/co-pilot]
Reduction of production cycle time	Activation characteristics [Catalysts, hardeners]	Increase of energy/work density at the work station [halogen lights, microcomputers]	Parallel processing, assembly lines [automobile manufacturing, Matrix computers]	Increase of frequency [Newspaper production]
Reduction of product planning and setup time	Standardized stock, modular construction components [Rolled steel, 4x8 panels, DIN paper]	Utilization of standardized (modular) process elements [Canned cycles in NC machines]	Modular machines, handling systems [Flexible manufacturing systems]	Automatic tool/ parameter changing, robots [Computerized plant change over]
Increase in ecological responsibility	• • •	• • •	• • •	• • •

Fig. 11. Implications and goals of process operations.

And now, since I use it nearly every day, the model has led me to consider both education about technology and education through technology.

As we continue to provide technology education, it is possible to systematize this approach, and to improve its reliability and validity as well as.basic consistency. It will include the following areas:

- the laws and principles of technology,
- the structure of technological processes,
- the design of technical products and
- the process and principles of innovative thinking.

Also, with such a modular concept of technology, innovation and work, we have a framework for building a database of examples which can be used to support an integrated technological education system that incorporates schools, industry and work. Then we will have an area for future research in order to help teachers set up technological projects. Let us go in to some details.

1. When one combines the constants of objectives with the constants of technological processes, the planes of an overall model are given. One starting point is the invariants of the human-technology-interface like using, testing, serving, assessing, recycling.

2. The second plane is formed by combining the constants of processes, and objectives. Then, by adding the constants of technological interaction sites, a three dimensional model is produced that represents a matrix of technological activity. Selected contraversial examples might include (see Figure 12):

- Energy transport in space
- Energy storage in water
- Material transport in hospitals
- Material forming in space
- Information storage in water
- Information processing factories.

Those are not merely academic musings or wishful thinking. Immediately behind them are answers to questions regarding the emerging possibilities of technological capacity. For example, and rather practical than the previous examples, are:

- Lasers as surgical tools
- Lasers as dynamic measuring devices
- Electrophoresis gene identification
- Biotechnology for use in coal mines, etc.

Furthermore, the emergence of such technological possibilities brings with it an opportunity to incorporate forward-looking aspects of education of curricula for technology and, to learn at the same time, how to use heuristic knowledge for mobilizing our thinking.

3. The constants in the Human-environment relationship, such as using, evaluating, etc. can be checked against other planes of the model in order to study new interaction fields.

With this concept of modular planes, one has a useful methodology for organizing the variety of technological applications/examples; while on the other hand, it enables teachers and

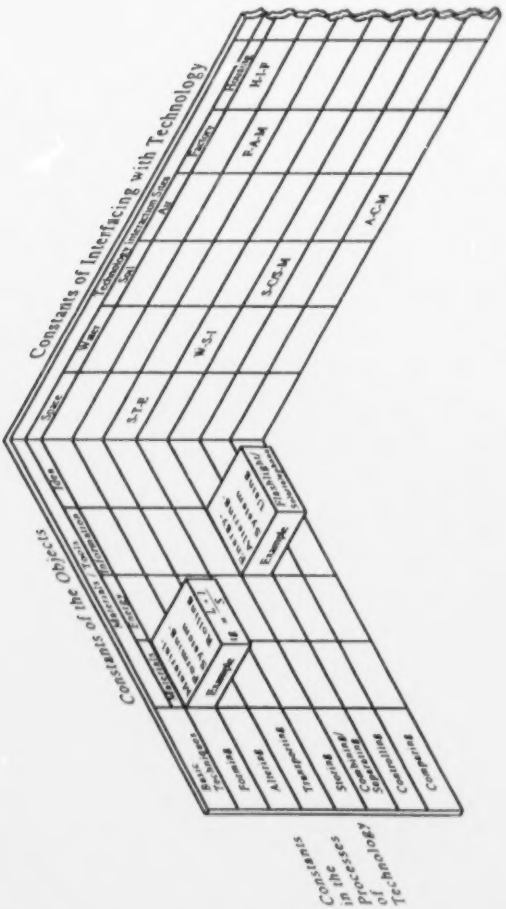


Fig. 12. Model planes: Constants of technological processes vs objects vs interaction sites.

teacher trainers to generate thousands of ideas and examples for teaching activities and the furthering of innovative thinking.

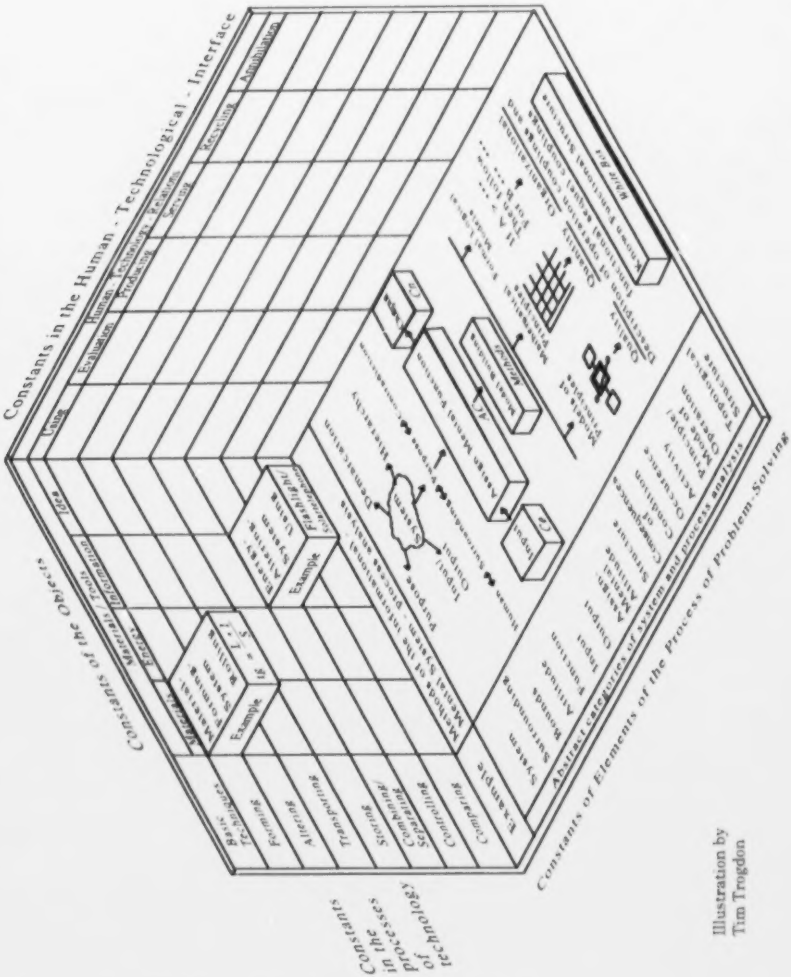

Constants in the Human - Technological - Interface
Constants of the Objects
Constants of Elements of the Process of Problem-Solving
Constants in the Processes of technological Work
Illustration by
Tim Trogdon

Fig. 13. The modular concept of technology and work.

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Second consequences

From the modular concept we can think of other alternatives:

- The same function can be realised through different structures.

- Correlations exist between function, shape, manufacture and materials for determining a compromise system (see Figure 14).

- The numbers of processes can be structured and classified according to their characteristics (forming, transporting, converting, warehousing, storing energy and processing information).

- All processes can be based on a model of active principles in order to change the operant conditions from Z_i to Z_{i+1}, see Figure 15.

- The active principles can use an analog or homolog as the starting point of morphological frameworks for product developments.

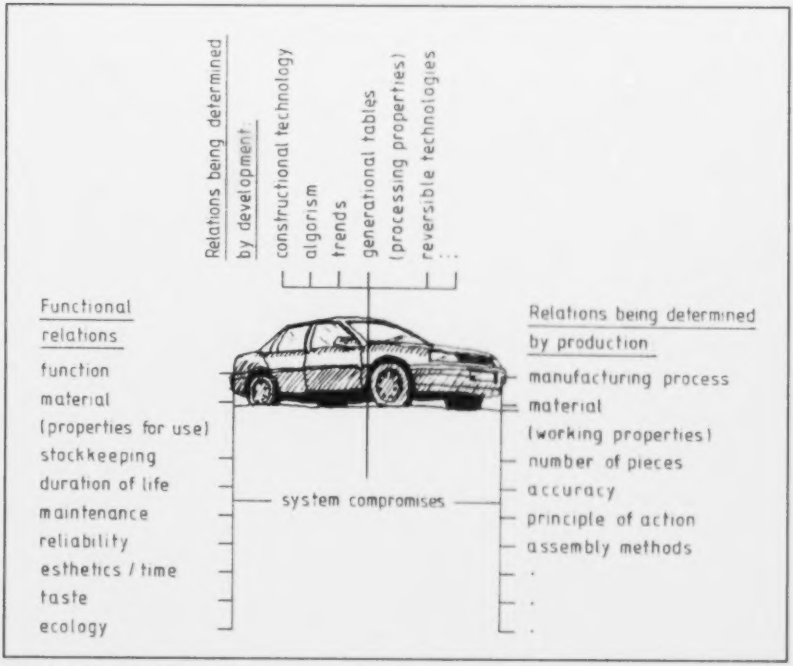


Fig. 14. Compromise System.

- The typical levels like needs, target, functioning principle, technical action principle, technical principle, dimensioning, can be used in processes of composition and decomposition.

- The hierarchical structure for evaluating user characteristics and technological assessment starts with the assumptions:

- Ecological Cleanness = maximum
- Sureness = maximum
- Life Quality = maximum
- Environmental Reflection = minimum
- Ideal-Reality-Difference = minimum

To use these insights as resources for pedagogical processes, we need more insight into the pedagogical situation itself. Therefore, not only we have to structure the objective and principles of the processes, but also to determine the capabilities of the humans themselves.

Technology Capabilities

All learning involves overcoming barriers and the role of education is to identify situations that help people develop the abilities to overcome barriers. It should be acknowledged, that human-technology interactions are a focus for development thinking. This has been agreed around the world, but it was known at the time of the fable about Icarus.

The example of Icarus illustrates an important fact - that we should not consider the school as an exile or prison, because he was forced to learn

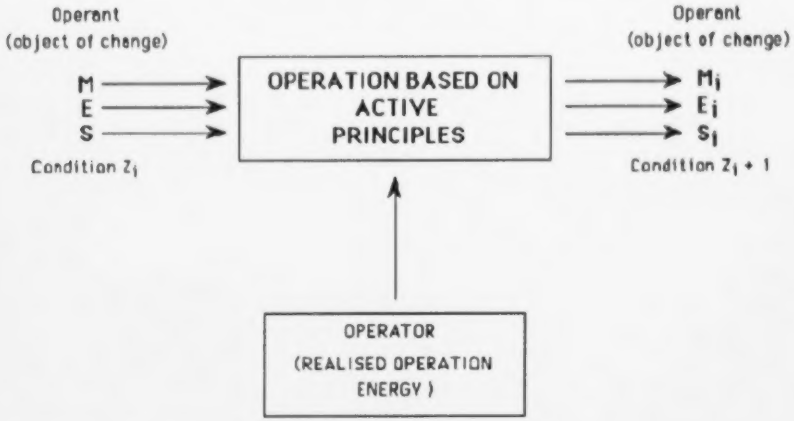


Fig. 15. The basic model to show an active principle.

Fig. 16. The fable of Icarus and Daedalus.

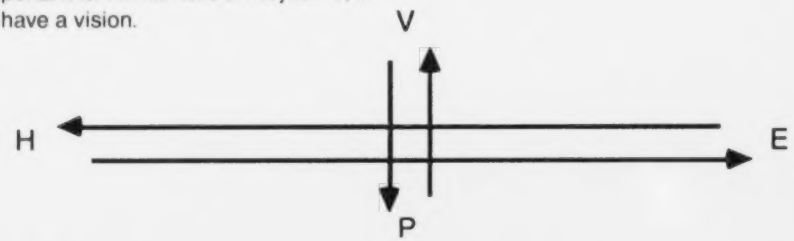
to survive - and to translate his wish for freedom into activity. His vision of a wider future, and seeing the freedom of birds flying over him, triggered him to model their wings. The conclusion is well known (Icarus went higher and higher . . .). This example has a lesson for today; it is shown in Figure 17.

When we ask for an answer, we must be prepared to evaluate it too. Icarus made wings and attempted to escape. But before doing so, it was very important for him to have an objective, to have a vision.

Problematic situation (thought initiator) → Overcoming thought barriers → imagining a vision of a possible solution → model development (resolution of contradictions) → development of approach strategies → development of time and activity plan → execution of the plan → evaluation of the results → new situation/problematic situation

The cycle is important today. The example of the fable shows us today, as it did in the past, the relationship between the tangible world and our mental concepts of it, in order to translate our ideas into practice via a systematic strategy. In the following figures, we depict these concepts albeit with the addition of time and economics as factors, see Figure 18.

But this example also shows us barriers to our thought processes and how difficult it is to overcome them. The problematic situation was the starting point/initiator for all the acti-



V: Vision, H: Human, P: Purpose, E: Environment; S: Situation

Fig. 17. Basic relations for starting points.

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vities. Icarus had no concept relating to the warmth of the sun affecting his ability to fly high. In order to properly judge a situation, technological or otherwise, we must be aware of all its aspects.

However, we do not need to think of Icarus to recognize the lesson of his example. Consider the many calamities and problems that we have experienced recently: The Tacoma Narrows Bridge collapsed in 1940; various, dam disasters, the garbage avalanche, chemical catastrophes (Bophal), rocket explosions, Tjernobyl, hormone scandals and airplane crashes with a frequency that has almost made us become accustomed to them. The world experiences a new

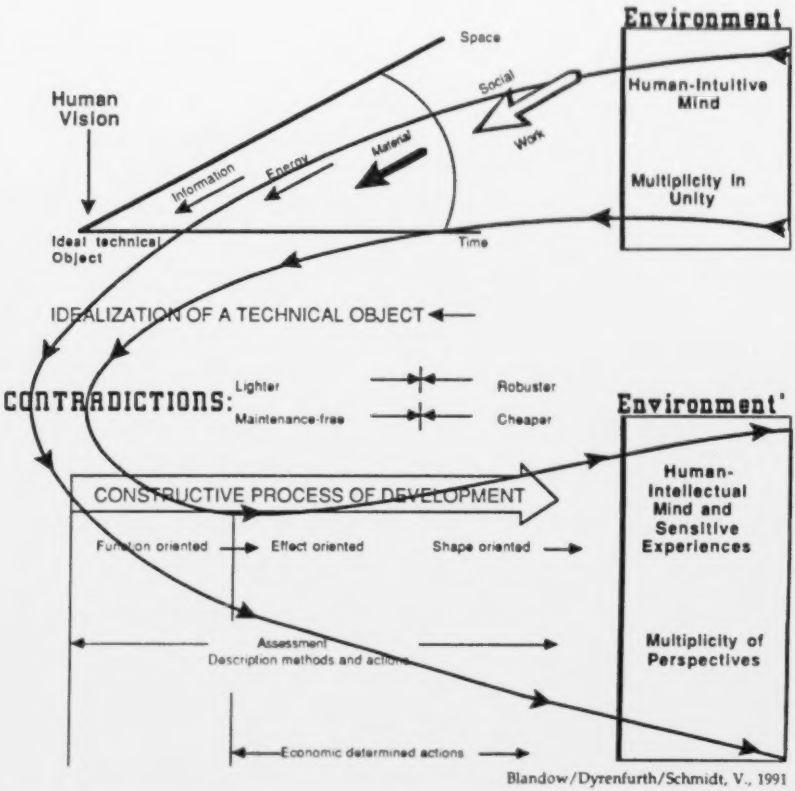

Fig. 18. Concrete - abstract - concrete - dynamic of technological competencies.

Icarus daily! However, today, the consequences of such failures affect many more people. Due to the power of technology, its consequences are felt by all humanity. This new dimension, namely that we are all involved,

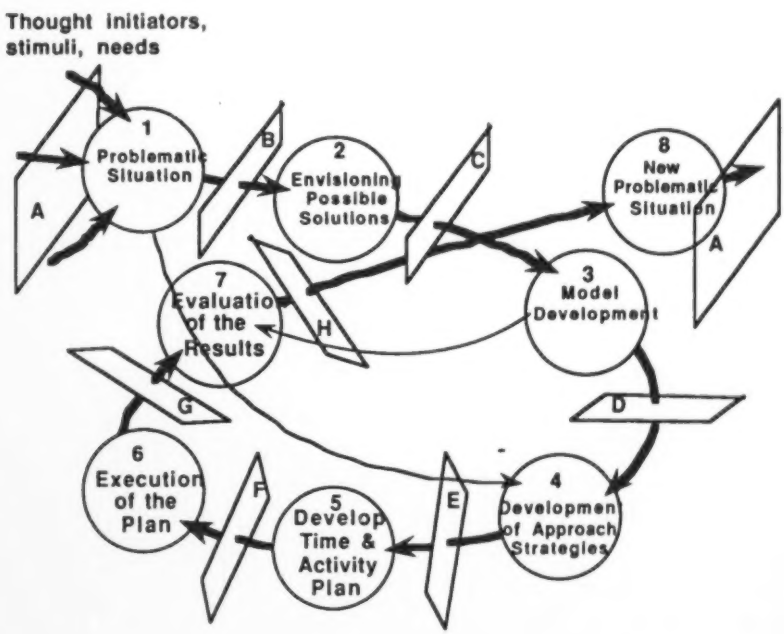

Fig. 19. Stages of the innovation process and typical barriers.

has consequences, that solving problems requires overcoming thought barriers first. Such an approach needs a wide awareness that cannot be obtained solely at school - it necessarily requires an active involvement with the problem and its whole environment. Given the problems, it becomes clear that current education does not develop awareness or make people sensitive to potential effects of technology or associated systems.

How can we help people to develop the skills for overcoming barriers? Obviously by beginning with basic concepts, considering the simplest proposition that combines the objectives between the starting point and the process for achieving them.

Some typical barriers between the stages are shown in Figure 19. Furthermore, the entire process is set in a context that also colors/affects the process itself. This is depicted in the following illustration, Figure 20.

Together with the product levels (functional principle, active principle, designing, ...) and the typical methods or intellectual tools for changing over from one level to another (Trend Analysis, Generation Tables, Need-Aim-Integration, Determining Contradiction, Setting up Compromises, ...) we have got the concept of Figure 20. The basic structure of the two step model (Figure 20) involves the analysis steps for everyone to use, abstraction, evaluation, etc. Here we also find the key for a teaching strategy. For example looking at students at the age 15+ years trying to find an alternative energy source for a cycle lamp we need an abstraction to the law of induction and from there we can ask for every alternative. But if we were to ask for other energy alternatives, we can change the active principles. Would we change the system, the bycycle as an element of a traffic-system, we again have other alternatives. On the grades 12 to 15, you can also work with the strategy of explaning the black box and its functional principles. (For windmills, the same function can be realised with different structures, etc. .).

With the structure of the levels and the intellectual tools to go from one level to another we have the preconditions for defining technological capabilities, see Figures 21 and 22. The competencies (or capabilities) are oriented to learning the appropriate knowledge and technological behaviour. They are based on:

- learning a metalanguage
- learning deconceptualising
- learning conceptualising
- learning contradiction and active principles
- learning variables und compromises
- learning assessment and evaluation
- learning workplace order.

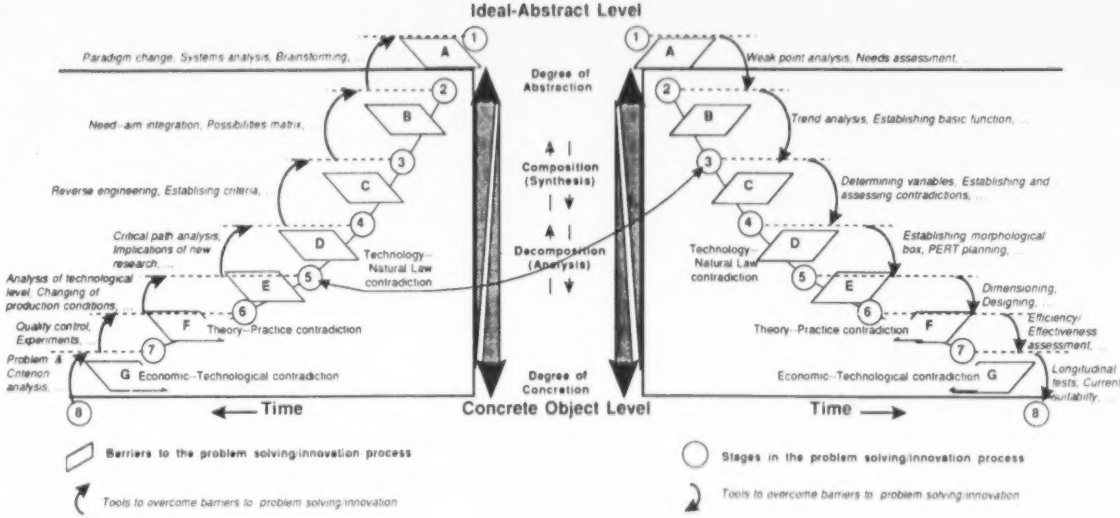
Ideal-Abstract Level
Paradigm change, Systems analysis, Brainstorming, ...
Need - aim integration, Possibilities matrix, ...
Reverse engineering, Establising criteria, ...
Critical path analysis, Implications of new research, ...
Analysis of technological level, Changing of production conditions, ...
Quality control, Experiments, ...
Problem & Criterion analysis, ...
Technology--Natural Law contradiction
Theory--Practice contradiction
Economic--Technological contradiction
Degree of Abstraction
Composition (Synthesis)
Decomposition (Aperysis)
Degree of Concretion
Time
Concrete Object Level
Weak point analysis, Needs assessment, ...
Trend analysis, Establishing basic function, ...
Determining variables, Establishing and assessing contradictions, ...
Establishing morphological box, PERT planning, ...
Dimensioning, Designing, ...
Efficiency/ Effectiveness assessment, ...
Longitudinal tests, Current suitability, ...
Time
Barriers to the problem solving/innovation process
Tools to overcome barriers to problem solving/innovation
Stages in the problem solving/innovation process
Tools to overcome barriers to problem solving/innovation
Brandes/Dyrenfurth, 1991

Fig. 20. Overview of problem solving, innovation stages, barriers and characteristic tools for implementing solution strategies.

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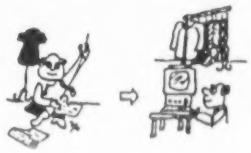
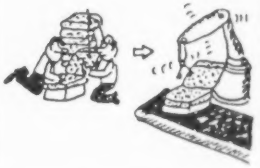
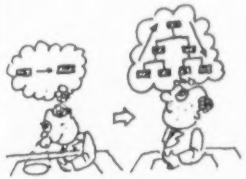
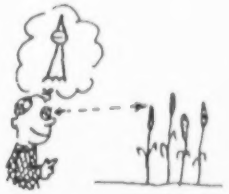
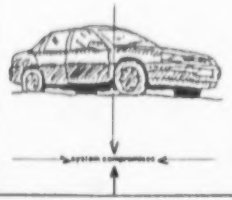
Fig. 21. Technological competences I.

Subcomponents of Technology Education

Thinking in stages of development	Thinking based on Interactive Ideas	Thinking in Terms of Variables and Decisions	Thinking in Terms of Technological Assessments
			
Thinking in Complexity	Thinking in Terms of Hierarchical and Time Oriented Systems	Thinking in Analogies	Thinking in Terms of Contradictions and Compromises
			

Blandow/Dyrenfurth, Winter 1992

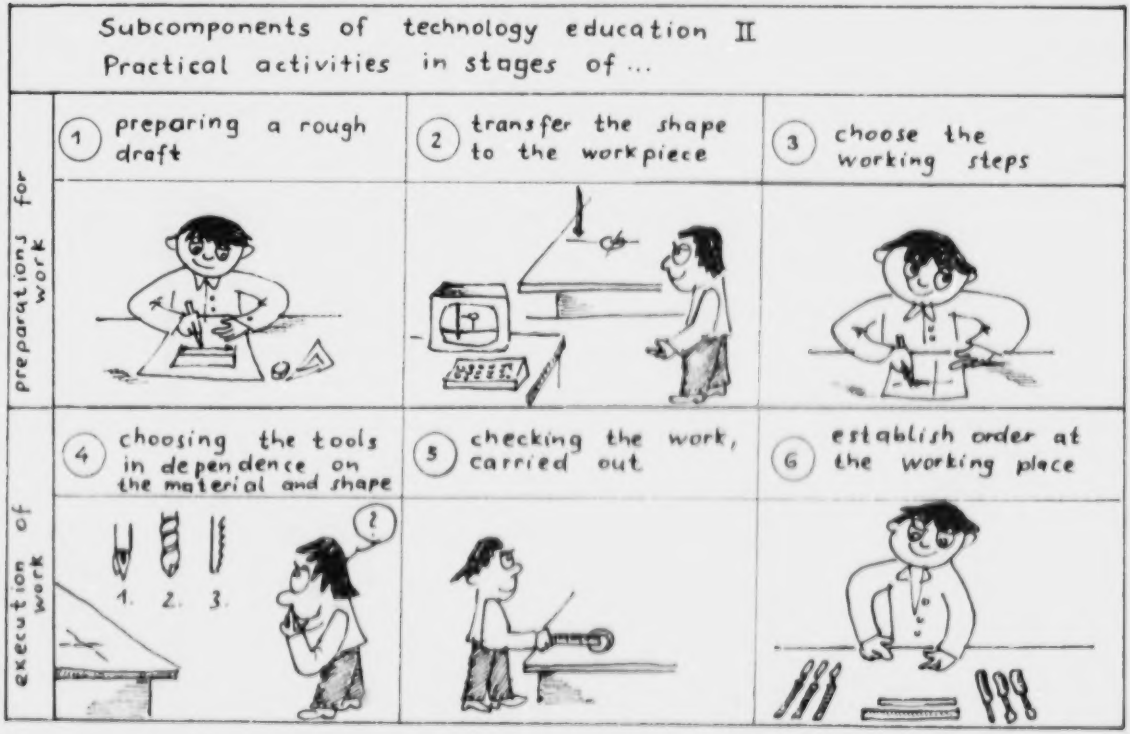

Subcomponents of technology education II
Practical activities in stages of ...
preparations for work
execution of work
1 preparing a rough draft
2 transfer the shape to the workpiece
3 choose the working steps
4 choosing the tools in dependence on the material and shape
5 checking the work, carried out
6 establish order at the working place
1. 2. 3.
?

Fig. 22. Technological competences II.

The sub-components of technological education can be expanded according to the age and interests of the students.

Implementation model

We may approach the basic principles in various ways. Some specialists will consider the activity as significant, others will consider the systems characteristics, while a third group could emphasize the aspect of social relationships. We may (moreover, have to) discuss it. We should, however, go beyond the debate and tolerantly look for those viewpoints which are common. I think those of my colleagues who think within the framework of the basic categories matter-energy-information and intellectual tool-system-model would not deny the importance of activity, construction and application, and vice versa. Similarly those colleagues who think within the framework of the economical and social relationships of technology would not deny the importance of aspects of household economy, preparation for life, or professional orientation, and vice versa. I think, only the stress is different, and they do not touch the very essence of our common endeavour.

As a useful tool for the implementation of technology as a school subject, we have - as a result of the ERASMUS-project Erfurt, Eindhoven and Leeuwarden - developed the Morphological Box, shown in Figure 23. This model combines the possibility of composition and decomposition of projects. Combining of the stages of cognitive development with the stages of interests and activities allows the subject area to offer a strategy for thinking and acting. The box helps reduce the world of complexity to models of acceptance. The box helps to adapt a general scientific model to the actual problems. But also, it helps to adapt it to the person involved. Here, the term didactical simplification for setting up meaningful activities can be used.

From this model, we can visualize the framework and the subjects needed for the curricula as described in Figure 24. For setting up special projects, you should see from Figure 25 that we should start with user characteristics. They are typical levels situated at the human technological interface. Then, we should go over to the structure of the processes and the products themselves.

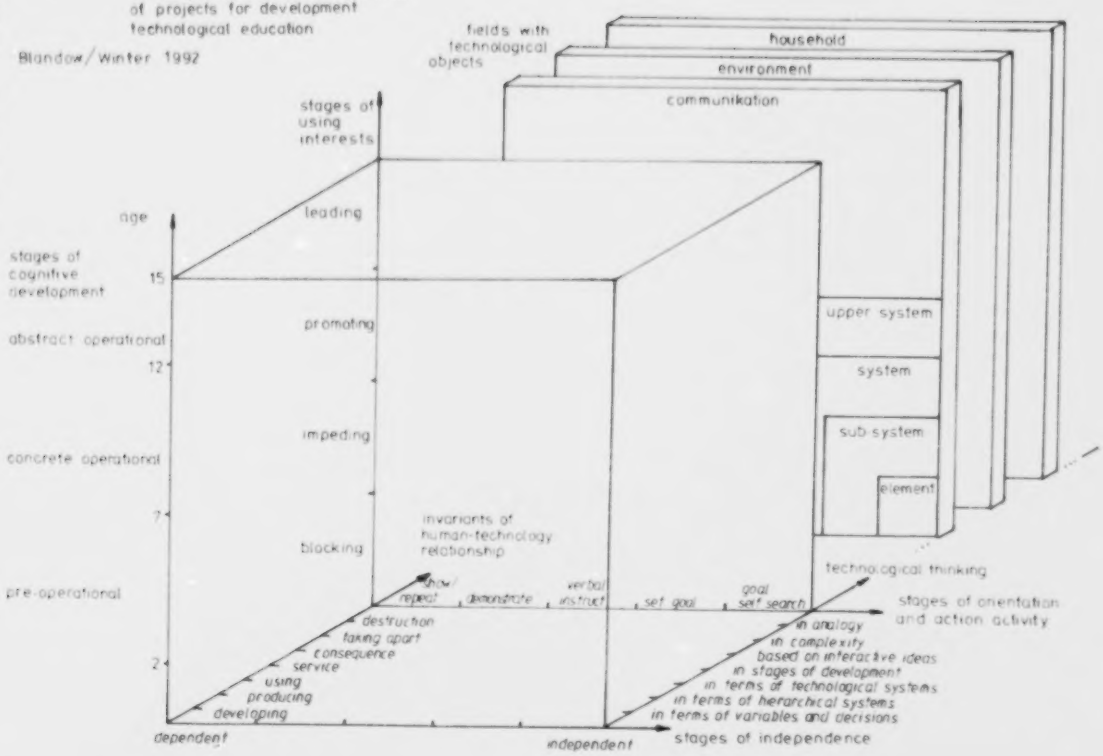
To work with and in the field of technology, like all other subjects; it needs the knowledge and the principles of the subject area as preconditions for pedagogical activities. To understand the system compromises, the knowledge about the elements, the basic contradictions, or the principles that frame the solutions, will be the tools needed. From the catalogue of knowledge elements and basic principles, the most suitable principles are shown in the conclusion.

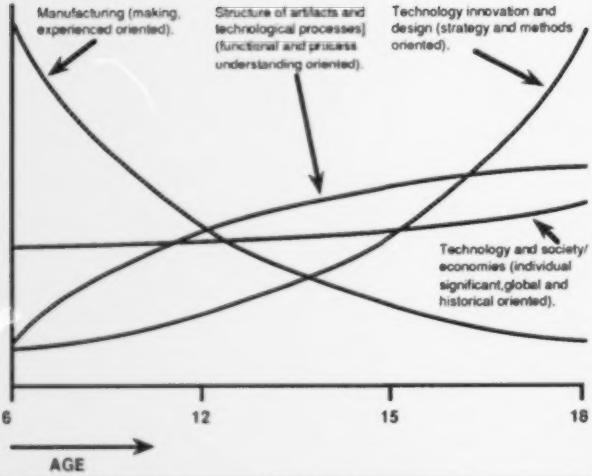
Fig. 23. Morphological Box.

Figure **Morphological Box**

for composition and decomposition of projects for development technological education

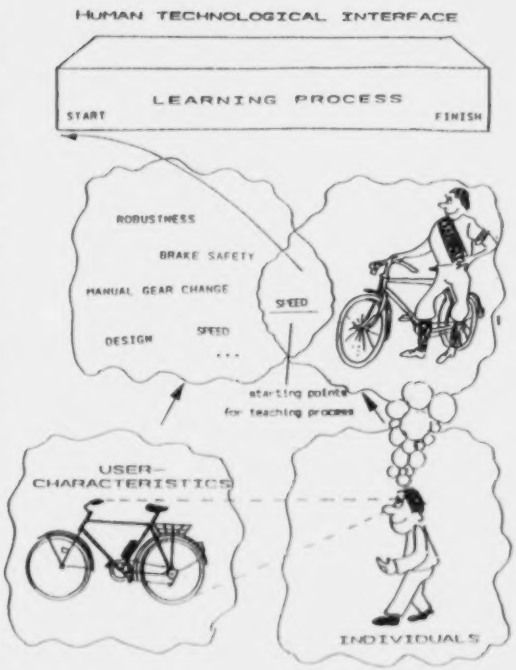
Blandow/Winter 1992




Manufacturing (making, experienced oriented).
Structure of artifacts and technological processes] (functional and process understanding oriented).
Technology innovation and design (strategy and methods oriented).
Technology and society/ economies (individual significant,global and historical oriented).
6
12
15
18
AGE

Selected topics from the framework model (based on a modular concept)		
- Working with paper , wood, textiles, natural materials	- User characteristics and evaluation	- Life-stages of a product
- Selecting and handling tools related to materials and products	- Technology in our life (environment, traffic, repairing and serving,)	- Trend analysis and succes parameter
- Technology in our houses	- Function and structure of machines	- System analysis, ideal product
- Working with construction kits	- Risks and resources of technology	- Contradictions and compromises
- Making models of known things	- Principles of technology	- Production and recycling
		- Social impacts of technology
		- Standards and laws in Europe
		- Economy and technology
		- Traffic and housing energy concepts

Fig. 24. Framework Model.



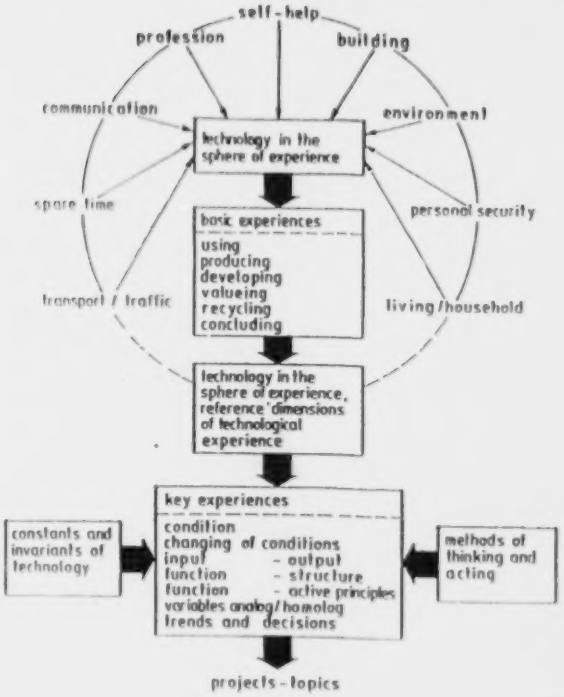


Fig. 25. Basic Structure of Technology Projects.

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Catalogue sheet: Principles of Technology

1. Principle of the effects of natural laws.
2. Principle of the diversity of how to realize purposes (homology).
3. Principle of the multi-purpose nature of special natural laws (analogy).
4. Principle of the basic elements of machines: Driving, control, optimizing, supporting, transmitting and working elements of machines for material-, energy- and information processes.
5. Principle of the conditional constraint (using, local, time, economical).
6. Principle of transformation and integration of the function between man and machine.
7. Principle of reversible technological processes (recycling).
8. Principle of realizing the processes through connected materials-, energy- and information flows.
9. Principle of combining partial functions into a variety of functional systems.
10. Principle of contradictions and compromises (relative optimum).
11. Principle of changing the position of partial functions within a hierarchic system.
12. Principle of anhomogeneous development, principle of the existence of weak points.
13. Principle of using more and more results from the microcosmos for effects in macrocosmos.
14. Principle of using functional-, structural- and organizational analogies from nature (also evolutionary).
15. Principle integrating the flow of materials, energy and information, (functional integration).
16. Principle of rhythm.
17. Principle of the multiple use of partial function elements.
18. Principle of functional realization through variation.
19. Principle of time and space hierarchy systems of oriented assessment (user characteristics).
20. Principle of realizing the main function through combining functional elements according to their sub-functions.
21. Principle of multiplication and minimization.
22. Principle of higher density at the working points.
23. Principle of using all the characteristics of materials, energy and information.
24. Principle of interdisciplinary development of technological systems.
25. Principle of process development and flexible products.
26. Principle of benefitting from disadvantages.
27. Principle of ideal products and processes.

For further research, I would like to find out the correlation between types of activities in a subject area and the interests of students age 12 to 15. For the

group 15+ it would be very interesting to start a course for young inventors. The question is how to develop their interests for technological subjects via innovation-oriented optional subjects. I hope that we will have a chance to influence the situation, that more and more students will look for other subjects than mathematics and/or engineering subjects. But at the same time we should invite our Eastern European Colleguages via Tempus Projects which will help them to reach a better orientation and to restructure their production- oriented framework.

Naturally, for such kind of work, you need courage, spirit and many alternatives as well as open minds of colleguages. For the oppurtunity to experience these changes and to think about them as a former Eastern European I must personally thank the College van Bestuur aan de Technische Universiteit Eindhoven and the Stichting Didactiek der Technische Wetenschappen te Eindhoven. But I also thank my wife and my son who have had to do without a man in the home for long periods of time. I thank Jan Raat for his confidence, (refers his Afscheidscollege) also thanks to the Dutch students for helping me to understand the local situation.
Thanks to my own Doctorial Students for their creative and optimistic help. And finally I would like to say thanks to the international family of technological teachers and educators who kept in a high spirit in difficult hours.

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